Descriptive text of physiological charts (90 pp., including small reproductions of the charts which he published in conjunction with LAURENT); Letter prefatory to DE WILDEMAN'S *Flore des Algues de Belgique;* An elementary lesson on Darwinism (106 pp.; an admirably clear and brief presentation, which appeared first in 1900 and is now printed as he had revised it for a third edition). This volume closes with three posthumous articles: Plants in contrast with other beings; What there is in a plant; The *épopée* of a ray of sunlight.

These volumes, as well as the more strictly scientific ones, will form a worthy memorial of this distinguished *savant*, whose writing is always luminous and inspiring. His bibliography, though voluminous (287 titles, as we learn from an interesting biography just published[9]), is remarkable, not alone for its extent, but for its value. To have all his work collected is a real boon.—C. R. B.

NOTES FOR STUDENTS

Papers on mucors.—Two valuable papers, largely taxonomic in character, have recently appeared on the mucors. In two ways they show an advance over other taxonomic work in this confused group. In the first place the center for fungus cultures maintained by the *Association Internationale des Botanistes* has been made use of, and the species investigated were compared as far as possible with named cultures from this and from other sources. Provided contamination of cultures in the source of supply is avoided, this center in Amsterdam affords a ready method of checking up determinations and should be of increasing value to mycologists. In the second place the differentiation of species according to their sexual character into homothallic and heterothallic forms is recognized as an item in the classification, and in heterothallic species the production of zygospores, when a given strain is grown in contact with the opposite strain of a known species, is used to establish its specific identity with the form tested.

HAGEM[10] announces his paper as a preliminary contribution to a study of soil mucors. By exposing Petri-dish cultures to the air and allowing the spores which fall on them to develop mycelial colonies, he finds with SAITO that spores of the mucors, both absolutely and relative to other molds, are unexpectedly of infrequent occurrence in the air. Only seven species were thus found. In investigating the mucor flora of the soil, samples from different kinds of soils were sown on various nutrient substrata, and the resulting growths isolated in pure cultures. Sixteen different species, confined to the genera Mucor, Rhizopus, Absidia, and Zygorhynchus, were found, of which six are described as new, viz., *Mucor strictus*, *M. sphaerosporus*, *M. griseo-cyanus*, *M. silvaticus*, *M. norvegicus*, and *Absidia glauca*. Four new forms are added to the list of heterothallic species. One of these, *Mucor hiemalis*, was especially investigated as regards the distribution in

9 FREDERICQ, LEON, AND MASSART, JEAN, Notice sur LÉO ERRERA, membre de l'Academie. 12mo. pp. 153. Brussels: Hayez. 1908.

10 HAGEM, OSCAR, Untersuchungen über norwegische Mucorineen, I. Vidensk.-Selsk. Skrifter. I. Math.-Nat. Kl. No. 7. pp. 50. 1908.

nature of the two sexual races. From a total of 52 separate isolations, 21 were of one sex, 5 of the other sex, and 26 (50 per cent.) failed to give any reaction with the test strains and were listed as neutral. Three of the strains that took part in zygospore formation were very weak in their sexual activity, and one of them under further culture entirely lost its power to take part in zygospore formation. The distribution of the sexual races in this species is thus shown to be in accord with the condition in Rhizopus, where out of 59 strains investigated by the reviewer, 19 were (+), 27 (−), and 13 neutral. The large percentages of neutral races thus established for these two species, together with the reviewer's own experience with neutral races in other heterothallic species, renders it probable that sexual neutrality is a widespread phenomenon among the mucors. There is little at present known to indicate its cause or significance.

LENDNER,[11] in his studies of the Mucorineae of Switzerland, has not confined himself to mere local species, and though he has not attempted to present an exhaustive treatment of the whole group, he has given us a more or less critical arrangement of the genera Mucor, Rhizopus, and Absidia. In these three genera keys for the determination of species are given, and each form is described, either from the original description or from A. FISCHER, with additional notes on such species as he had himself cultivated. In classifying the genus Mucor, FISCHER'S division into the unbranched, racemosely branched, and cymosely branched groups is followed. Fifty-one species are recognized, of which seven, *M. lausannensis*, *M. genevensis*, *M. pirelloides*, *M. lamprosporus*, *M. Jansseni*, *M. spinescens*, *M. dimorphosporus*, are described as new species, and one, *M. adventitius* var. *aurantiaca*, as a new variety. BAINIER'S genera, Parasitella and Glomerula, are reduced to the genus Mucor, as also VUILLEMIN'S Zygorhynchus. The genus Mucor is the Crataegus among fungi and will probably always remain a taxonomic playground for mycologists. One might imagine that early systematists used the genus as a group to practice on, and their one- or two-line descriptions are frequently hardly sufficient to tell us whether the form described is a mucor or a myxomycete. Such supposedly common forms as *Mucor Mucedo* and *M. racemosus* among others, it is impossible to determine with any degree of accuracy, and therefore these designations can be considered hardly more than group names. We cannot but have considerable charity toward one who feels inclined, in consequence, to disregard the stock names, but when each mycologist who works on the genus gets out a list with names of his own, the result is confusing to a degree. Moreover, species shown to be distinct by the reaction between their sexual strains are frequently so closely related and vary so widely under different conditions of cultivation that the usual description is insufficient to distinguish them. LENDNER has done a service in bringing together the descriptions of species since FISCHER'S publication. We are grateful that he has not found it necessary to make new species out of more than 15 per cent. of the 51 forms

[11] LENDNER, ALF., Les Mucorinées de la Suisse. Matériaux pour la flore cryptogamique Suisse. Vol. III, Fasc. I. pp. 180. 1908.

listed. Seven circinellas are described, of which *C. minor* and *C. aspera* are given as new. In the genus Rhizopus, of which 22 species are recognized, physiological characters, such as ability or inability to grow on potato above 39° C. and power to ferment different carbohydrates, are used in addition to the usual distinguishing morphological characters. Material received from the Amsterdam center under the name of *Mucor norvegicus* is identified as *R. nodosus*. Seventeen species are recognized in the genus Absidia, of which *A. spinosa*, a homothallic and heterogamic species, is described as new. In addition to the forms from the genera mentioned, *Cunninghamella elegans* is described as new.

In addition to the systematic part of 113 pages, an introduction of 47 pages is devoted to methods of isolation and cultivation, and to a discussion of the sexual reproduction in the group, together with the results of a cytological investigation of the formation of zygospores. It might be expected that forms in which the sexual differentiation had extended to the separation of distinct male and female races would show a differentiation in the uniting gametes. In no heterothallic form, however, has there been shown to be any constant difference in the size of the gametes, such as occurs in a few of the homothallic species, where, since the zygospores are produced between neighboring filaments of the same plant, a less specialized sexual condition might be supposed to exist. In *Absidia Orchidis*, LENDNER finds that the circinate outgrowths, which typically arise from both suspensors, are at times produced from but one, which has been cut off from the large progamete that he considers female. This he claims an indication of sexual differentiation, as also the frequent inequality in the gametes of Rhizopus. From these facts he concludes that the (+) and (−) races are potentially homothallic, but with the opposite sex more or less completely suppressed. The suggestion that the sexual races may be potential hermaphrodites is in line with our knowledge of higher forms, but to formulate this as a conclusion and to claim that the smaller and larger gametes formed by a single sexual race are male and female respectively, as LENDNER would imply, is certainly going beyond the facts in hand. The reviewer has shown that in Rhizopus the larger gamete is derived sometimes from the (+) and sometimes from the (−) plant, and that similarly in the heterothallic species of Phycomyces the outgrowths (which LENDNER, p. 38, wrongly says arise from the zygospore itself) are confined sometimes to the (+) and sometimes to the (−) suspensor. The inconstant difference in size of gametes and behavior of outgrowths from the suspensors in *Absidia Orchidis* is probably merely nutritive in character and of no sexual significance. In *A. Orchidis* also, is figured what appears to be an arrested stage in the formation of a zygospore between two outgrowths from the same suspensor, and therefore belonging to the same sexual race. If this is used as an argument for the contention just mentioned, the fact should be established beyond doubt. Even if the author were not mistaken as to the terminations of the filaments apparently in conjugation, which would be difficult to follow in a tangle of other filaments, these two arrested gametes might be thought to have arisen adjacent to each other at the stimulus of contact of a third branch, which came from the opposite sex but had remained in only temporary contact with them.

No two investigators are as yet in accord as to the cytology of the zygospores of the mucors. GRUBER, who apparently has done the most careful work on the zygospores of Sporodinia, was unable to find a fusion of nuclei at any stage in their formation or maturation, and several of the most experienced of American and European cytologists of the fungi have personally told the reviewer that they also have investigated the zygospores of this same species, but with no better results. In 1906, DANGEARD, working with *Mucor fragilis*, described the uniting cells as gametangia and saw a fusion of nuclei in pairs soon after the union of the two sexual cells. The condition in Sporodinia was more difficult to follow, but DANGEARD believed he was able to find the same condition in the zygospores of this species. LENDNER, in the work before us, criticizes the conclusions of DANGEARD, claiming that the figures which DANGEARD interprets as stages in fusion are in fact stages in division, since they occur at the same time in the two suspensors as well. What DANGEARD considers as degenerating supernumerary nuclei toward the periphery of the zygospore, LENDNER never finds in degeneration, and he believes them to be in this position to preside over the formation of the membrane. The real sexual fusion, according to LENDNER, is between two large nuclei which approach the center of the zygospore. The two densely staining bodies in the fusing nuclei, which are homologized with chromosomes, give at first four bodies in the fusion nucleus, that eventually are reduced to two and finally unite into a single mass. Neither DANGEARD nor LENDNER has studied the germination of the zygospores.

Since KLEBS showed that external factors are responsible for the form of reproduction in Sporodinia and many other fungi, the influence of external conditions upon the growth and reproduction of individual species has become a favorite subject of investigation. As the reviewer has shown, external conditions are more influential in determining the form of fructification in the two homothallic species of Sporodinia and Dicranophora, found growing on fleshy fungi, than in the homothallic species, *Zygorhynchus Moelleri*, recently investigated by WISNIEWSKI,[12] a pupil of RACIBORSKI. It seems to be generally true in regard to the influence of external conditions, that the limits within which zygospore formation is possible are narrower than those within which sporangial formation occurs. WISNIEWSKI finds that, although under ordinary conditions sporangia are formed together with zygospores on the same mycelium, extreme conditions may suppress the production of zygospores, while sporangia are still formed. On pure agar below 5° C. and on the same substratum in direct sunlight, only sporangia will be produced. (It may well be the heat rather than the light effect of the direct rays of the sun that is here influential.) Under all other conditions examined, both zygospores and sporangia were produced together, if at all. The decrease in relative abundance of zygospores is associated with a checking of the rapidity of growth of the mycelium. The transpiration is shown to have no effect upon the

[12] WISNIEWSKI, P., Einfluss der äusseren Bedingungen auf die Fruchtform bei *Zygorhynchus Moelleri*. Bull. Acad. Sci. Cracovie Cl. Sci. Math. et Nat. **1908**: 656–682.

rapidity of growth, and it is assumed that for this reason increase or decrease of moisture in the surrounding air does not affect the proportion between zygospores and sporangia. Upon certain substrata, zygospores are more abundant at the junction of adjacent mycelial colonies, forming dark lines. The conditions governing their production have not been investigated.

For several years DAUPHIN has been interested in the genus Mortierella. In a recent paper on the genus[13] he gives in 28 pages a systematic arrangement of the species as an introduction to a special study of *M. polycephala*. The original descriptions and figures are given for each of the 29 species and varieties discussed. Two new species, *M. canina* and *M. raphani*, and one new variety, *M. van Tieghemi* var. *cannabis*, are described. The genus is divided into four group species (*grandes espèces*) with subspecies (*petites espèces*) and varieties under them. A well-arranged key would have added to the value of this part of the work. *M. polycephala* is the only one of the Mortierellas which has been investigated in regard to the influence of external conditions upon the production of zygospores. In this species, which forms the subject of the physiological part of the paper, DAUPHIN has succeeded in finding the zygospores, and since he obtains them from sowings of single spores, he classifies the species as homothallic. This being the case, it seems strange that they have not been found in this form by other investigators, since as yet no neutral strains have been found for homothallic species. The optimum temperature for germination of the spores is placed at 27° C., and the optimum for formation of sporangia and zygospores, between 15 and 20° C. Germination and growth are checked by darkness, but the fructifications are not altered. Light increases the rapidity of development, but if too intense causes the fructification to be confined to stylospores. The violet and ultra-violet rays of the spectrum seem necessary for the germination of the spores. X-rays and the influence of radium are inhibitive to germination and growth, the radium in addition causing the production of cysts in the hyphae. Moisture in the surrounding air is shown to be necessary for the germination and growth of the fungus. Perfect development will take place in an atmosphere completely free from oxygen. A decrease, however, of atmospheric pressure below 150^{mm} causes the mycelium to remain sterile. An increase of pressure above atmospheric checks the growth of the mycelium without preventing the normal fructifications. *M. polycephala*, like other mucors, develops poorly in liquid media. The monosaccharids, especially dextrose and levulose, were found most favorable of the carbohydrates for formation of zygospores and sporangia. The influence of different concentrations of the nutrient was little investigated, but stylospores and sporangia were produced without zygospores when the amount of dextrose was increased from 20 per cent. to 60 per cent. The purpose of this part of the paper seems to have been to find out the influence of a large number of more or less isolated external conditions upon the form of fructification, rather than to work out thoroughly the influence of a few closely related factors.

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[13] DAUPHIN, JEAN, Contribution à l'étude des Mortierellées. Ann. Sci. Nat. Bot. IX. **8**: 1–112. 1908.

It is hardly necessary in a botanical publication to comment on a recent note in *Science*, entitled *Mucor cultures*.[14] The author states that "in the study of the Mucoraceae for several years, some interesting facts concerning the development or rather non-development of zygospores were observed." In a thousand cultures of *Rhizopus nigricans*, made from material collected by the author or sent him by friends, as well as in five hundred specimens found growing spontaneously in different places, and in about five hundred other unrecorded observations of the fungus (a total of two thousand observations), no zygospores were found. Inoculations were made on a number of different media, including HAMAKER'S corn-bread-muffin combination, and the growth of the cultures was tested in closed jars in H, N, and CO_2. No zygospores were obtained, and the conclusion is reached that "the absence of oxygen is not a necessary condition for the growth of zygospores." It is a pity that one who has the time to make observations on 2000 cultures should not have taken the trouble to read the recent literature on the subject, to learn in what part of a culture zygospores are produced and under what conditions their formation is possible, and so be in a position to make a contribution of some value. Additional information in regard to the relative distribution in nature of the two sexual strains of this most common of molds might have been the fruit of so extended a series of observations.

Appended is a list of species, the thallic condition of which has been determined, arranged according to the type of their sexual reproduction. Following each species is given in parentheses the name of the author who has investigated the zygospores and determined the sexual condition of the species in question.

Homothallic

1. Sporodinia grandis (BLAKESLEE)
2. Spinellus fusiger (BLAKESLEE)
3, 4. Mucors I and II (BLAKESLEE)
5. Mortierella polycephala (DAUPHIN)

Heterogamic

6. Dicranophora (BLAKESLEE)
7. Zygorhynchus Moelleri (BLAKESLEE)
8. Zygorhynchus heterogamus (BLAKESLEE)
9. Abisdia spinosa (LENDNER)

Heterothallic

1. Mucor Mucedo (BLAKESLEE)
2. M. hiemalis (HAGEM)
3. M. silvaticus (HAGEM)

4–9. Mucors III–VIII (BLAKESLEE)[15]

10. Absidia Orchidis (HAGEM)
11. Absidia glauca (HAGEM)
12. Absidia caerulea (BLAKESLEE)
13. Absidia repens (BLAKESLEE)
14. Rhizopus nigricans (BLAKESLEE)
15. Phycomyces nitens (BLAKESLEE)
16. Circinella umbellata (BLAKESLEE)
17. Cunninghamella echinulata (BLAKESLEE)
18. Choanephora cucurbitarum (BLAKESLEE)
19. Helicostylum piriforme (BLAKESLEE)
20. Syncephalastrum (BLAKESLEE)
21. MUCOR N, n. gen. (BLAKESLEE)

—A. F. BLAKESLEE, *Storrs, Conn.*

[14] SUMSTINE, DAVID R. Science N. S. **29**: 267. Feb. 12, 1909.

[15] Perhaps some of Mucors III–VIII are identical with species already in the list.